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ON THE LIMITS OF PRECISION OF PHOTOGRAPHIC OBSERVATIONS OF ARTIFICIAL SATELLITES

By

M. Paul Muller

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ON THE LIMITS OF PRECISION OF PHOTOGRAPHIC OBSERVATIONS OF ARTIFICIAL SATELLITES *

Comptes-Rendus de
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By.
M. Paul Muller

A satellite leaves a trace on a negative of which it is tempting to define a certain number of points relative to stellar background, on the condition that one should be able to make correspond to each of them the time when the satellite passed at it.

The problem entails numerous new difficulties, for whose appropriate solutions we searched methodically. Since our last Note [1], our efforts were directed toward new points, and we think that we draw nearer a precision limit: that of catalogues of stars themselves.

TIME REFERENCE SCALE Desirous to rid ourselves of camera shutters, we choose provisionally a technique of declination shift. To that effect, we constructed and put into service early in 1963 a negative shutter with a blade which moves at 60 cm/s in front of the negative, carried by full rounds thanks to two closed "Galle" chains. At rest the blade disappears at the lower part of the chassis. Two contacts are closed to passage, one near the beginning, the other near the end of crossing in front of the negative, so as to determine by

*[Sur les limites de la précision des observations photographiques de satellites artificiels] - Note présentée par M. André Couder

[redacted]

interpolation between the two moments registered on a chronograph the moment of passage of each point of the negative.

Experience shows that the interval, near 300 ms stabilizes itself at 1 ms approximation immediately after the second tour; the operation is thus carried by series of 8 rounds.

The satellite trace is marked on the negative by short interruptions (of about 30 μ) of which the center can be pointed at with precision on a measuring device.

GUIDANCE The time exposure does not last more than 2 min. The observer maintains a star at the center of the sighting telescope and commands the start of each series of blade revolutions when it is aimed exactly. Small guidance deviations, unavoidable at any rate, can be tolerated under the condition that they spread in the two directions.

MEASUREMENT We dispose since July 1962 of a Zeiss reference scale device, providing rectangular coordinates with an approximation to 1 μ. The negative reduction is made as suggested earlier [2].

PRECISION OBTAINED The precision is controlled by smoothing satellite's position along the trace by an osculating orbit [3] or by an interpolation polynomial relative to time. There are several dozen positions. We may otherwise recognize the part which refers to marks on the interruptions, by reducing the stars along; the remnants provide the errors of connecting a star.

We have found for mean deviations:

Over a star: 0.9" per coordinate

Over a satellite: 2" per coordinate

To the extent of our knowledge, no such precision has been attained as yet, even by much more powerful means.

Knowing that the epoch of a reading may intervene for 1" (mean trajectory of the satellite in 1 ms), and the connecting for about 1" also, the total mean deviation of 2" leaves to the marking a little more than 1", say sensibly 2μ at the focus of our camera K37 (307 mm). In the general outline of this question, presented at COSPAR S.S. Symposium, Washington 1962, concerning the use of geodetic satellites, W. Markowitz ascribed 1"5 to each of the three causes; therefore there is progress.

However, our aim is to bring the error down to about 1". Where can we expect to gain still further?

As far as time is concerned, the shutter appears to be satisfactory: however, we shall replace the mechanical contacts by an electronic command. The chronograph remains to be considered. The Belin model at 1/100 becomes insufficient; we shall study a chronograph printing to 1/10000 the of a second, derived from an immediately available industrial device (Ferisol frequency-meter HA 101 B).

Measurements made on a negative might gain a little in stretching the focus and improving stellar images. for the purpose of testing, we reduced a film taken by the Schmidt telescope of Meudon (focal disance of 1 m), with the effect of reducing the mean deviation on the

stars to 0.4". With regard to the study of the so-called de Garchy camera (D = 300, F = 900), whose optics will be given particular attention, we plan a 200/600 camera, easily realizable, which should allow a better connection than the one described above.

Guidance poses a difficult problem, each of the positions of the satellite supporting without compensation the instantaneous drift. The fixed chamber would be more reliable, but it would then be necessary to mark the interruptions of duration, necessarily greater, on the star traces, and the advantage of aiming at round images would be lost. One might combine a fixed phase with a guidance phase (during satellite passage), as this was already successfully attempted by us.

At any rate catalogue of stars seems to impose a limit to the precision. Once the most brillant ones have been set aside, as giving too spread out images the fundamental stars are numerous enough on a negative. We take reference stars between the magnitudes of 6 to 8, so as to protect us from various possible errors (Magnitude equations) In this domain, the positions at better than 0.5" are not always certain namely because of own movements.

Taking into account the errors introduced by the aggregate of the technology, it appears to be difficult to expect a better precision than 0.5" to 1". The geodetic operations will be conducted over satellites distant from 1000 to 1500 km. The corresponding deviation at the ground is of the order of 5 meters, which would fully satisfy the geodesists in the cases reserved to satellites by the shortcomings of direct methods.

* * * THE END * * *

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Paris-Meudon Observatory.

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